PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :		(11) International Publication Number:	WO 98/38763
H04L 1/12	A1	(43) International Publication Date:	3 September 1998 (03.09.98)

(21) International Application Number: PCT/US98/00276

(22) International Filing Date: 13 January 1998 (13.01.98)

(30) Priority Data:
08/806,783 26 February 1997 (26.02.97) US

(71) Applicant (*for all designated States except US*): MOTOROLA INC. [US/US]; 1303 East Algonquin Road, Schaumburg, IL 60196 (US).

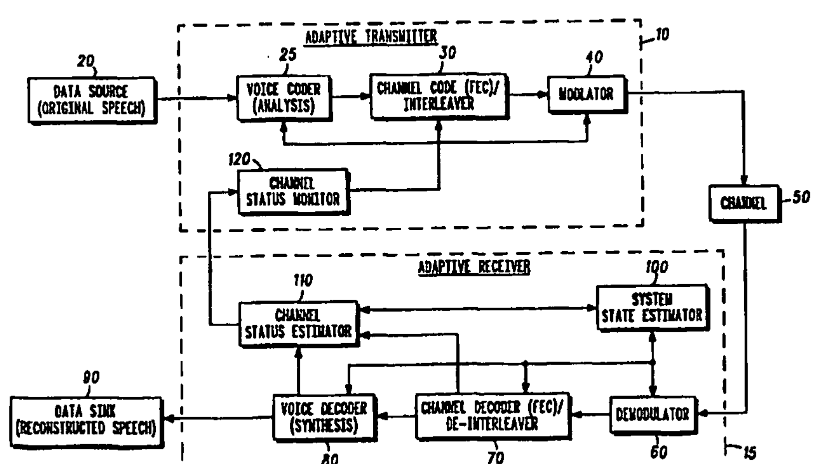
(72) Inventors; and
(75) Inventors/Applicants (*for US only*): KLEIDER, John, Eric [US/US]; 8501 E. Turney Avenue, Scottsdale, AZ 85251 (US). WOOD, Clifford, Allan [US/US]; 7227 S. Bonarden, Tempe, AZ 85283 (US). CAMPBELL, William, Michael [US/US]; 3953 E. Agave, Phoenix, AZ 85044 (US).

(74) Agents: INGRASSIA, Vincent, B. et al.; Motorola Inc., Intellectual Property Dept., P.O. Box 10219 M, Scottsdale, AZ 85271–0219 (US).

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: METHOD AND APPARATUS FOR ADAPTIVE RATE COMMUNICATION SYSTEM



(57) Abstract

A system is disclosed for an adaptive rate voice system to provide improvements in coded operation over changing communication channel (50) conditions. This adaptive rate system efficiently determines optimal voice/channel coding rates, coding strategies and modulation/demodulation for optimum voice quality and intelligibility. A system state estimator (100), channel status estimator (110) and channel status monitor (120) provide feedback in the system to optimize the communication channel. The system maintains a continuous link despite changing channel conditions and minimizes delays through the system. Even though simple in design, it provides relatively low complexity and powerful channel coding operation. Operating conditions are thus extended for CDMA and portable communication systems. Voice intelligibility is preserved in extremely noisy or even hostile channel conditions.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania
AM	Armenia
AT	Austria
AU	Australia
AZ	Azerbaijan
BA	Bosnia and Herzegovina
BB	Barbados
BE	Belgium
BF	Burkina Faso
BG	Bulgaria
BJ	Benin
BR	Brazil
BY	Belarus
CA	Canada
CF	Central African Republic
CG	Congo
CH	Switzerland
CI	Côte d'Ivoire
CM	Cameroon
CN	China
CU	Cuba
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
ES	Spain
FI	Finland
FR	France
GA	Gabon
GB	United Kingdom
GE	Georgia
GH	Ghana
GN	Guinea
GR	Greece
HU	Hungary
IE	Ireland
IL	Israel
IS	Iceland
IT	Italy
JP	Japan
KE	Kenya
KG	Kyrgyzstan
KP	Democratic People's Republic of Korea
KR	Republic of Korea
KZ	Kazakstan
LC	Saint Lucia
LI	Liechtenstein
LK	Sri Lanka
LR	Liberia
LS	Lesotho
LT	Lithuania
LU	Luxembourg
LV	Latvia
MC	Monaco
MD	Republic of Moldova
MG	Madagascar
MK	The former Yugoslav Republic of Macedonia
ML	Mali
MN	Mongolia
MR	Mauritania
MW	Malawi
MX	Mexico
NE	Niger
NL	Netherlands
NO	Norway
NZ	New Zealand
PL	Poland
PT	Portugal
RO	Romania
RU	Russian Federation
SD	Sudan
SE	Sweden
SG	Singapore
SI	Slovenia
SK	Slovakia
SN	Senegal
SZ	Swaziland
TD	Chad
TG	Togo
TJ	Tajikistan
TM	Turkmenistan
TR	Turkey
TT	Trinidad and Tobago
UA	Ukraine
UG	Uganda
US	United States of America
UZ	Uzbekistan
VN	Viet Nam
YU	Yugoslavia
ZW	Zimbabwe

METHOD AND APPARATUS FOR ADAPTIVE RATE COMMUNICATION SYSTEM

Background of the Invention

The present invention pertains to communication systems and more particularly to adaptive rate voice communication systems.

Present day digital voice communication systems are subject to degraded speech quality for changing channel conditions because of large variations in digital performance parameters such as bit error rate or received bit energy to noise density ratio. Such systems are only usable over a slight range of these varying channel conditions.

In a fixed aggregate rate system the source and channel coding rates are allowed to vary, but the whole sum of the voice coding bit rate plus the channel coding bit rate is constant. Thus, if the aggregate rate is fixed, the sum of the rates of the source and channel coding is equal to the aggregate channel rate. The prior art discloses the use of a variable rate speech and a variable channel coding rate, but at a fixed aggregate channel rate, the sum of the speech (source) bit rate and the channel coding rate always being fixed. In addition, such prior art systems also use a fixed modulation method.

Channel conditions include such parameters as: speech quality, intelligibility, the signal-to-noise ratio (S/N), symbol error rate (SER) and bit error rate (BER) of the transmitted and received signal. In typical wireless communication systems, degradation of the communication channel conditions may inhibit quality communication or may prevent communication at all.

Link margins of such communication channels experience long and short duration deep fading that distorts or inhibits communication. Such prior art voice systems are only usable over a slight range of these varying channel conditions. Similar conditions can occur for image transmission, digital data and other communication systems in addition to voice coding systems.

Accordingly, it would be advantageous to have an adaptive rate communication system that maintains a continuous link despite changing channel conditions and provides a relatively low complexity and powerful channel coding operation while being simpler in design and minimizing delays through the communication system.

Brief Description of the Drawing

FIG. 1 is a block diagram depicting an adaptive rate communication system such as a voice coder system in accordance with the present invention.

FIG. 2 is a portion of a receiver flowchart depicting the adaptive technique for an adaptive rate communication system in accordance with the present invention.

FIG. 3 is the other portion of the receiver flowchart depicting the adaptive technique for an adaptive rate communication system in accordance with the present invention.

FIG. 4 is a transmitter flowchart depicting the adaptive technique for an adaptive rate communication system such as a voice coder system or vocoder in accordance with the present invention.

Description of the Preferred Embodiment

In accordance with the present invention, a novel method and apparatus for an adaptive rate communication system for optimal voice coder speech quality and intelligibility is shown.

The basic system accepts an audio input from a data source such as original speech from a person. A voice coder or vocoder then converts the audio input to a digital form. Next, a channel coder processes the digitized audio to give forward error control or FEC and interleaving. This digitized audio is then modulated by a modulator and transmitted over a suitable communication channel to a receiver for demodulation.

The demodulator, channel decoder/de-interleaver and voice decoder of the receiver reconstruct the digitized audio. This is provided to some data sink as the reconstructed speech. Current state of the art vocoder systems use fixed aggregate rates for the transmitter. The channel coding FEC bit rate plus the vocoder rate is a fixed quantity. The novel system varies the modulation, FEC, and voice coder rate to achieve optimal channel operating conditions.

Variation of the modulation method is central since this achieves considerable gain in the system capability. Digital transmitted speech can withstand bit-error-rates (BER) of approximately 0.1 to 1 percent and still be of good quality. At this BER, coding gains for typical FEC systems can be less than gains from switching modem rates.

Complex FEC requires more computation than modulation changes. Thus switching modulation lowers the requirements of the system. Switching is based on an objective measure of the distortion in the data.

The current objective measure of speech quality or speech distortion indicator is based on a function of the vocoder parameters including spectral distortion, coding probability errors, pitch distortion, decision bit errors, gain distortion and others measures that could be added by those skilled in the art. This optimal vocoder system minimizes channel errors with minimal equipment additions.

Referring to FIG. 1, a block diagram of a typical voice communication system architecture employing an adaptive technique is shown. An adaptive transmitter 10 provides signals to an adaptive receiver 15. The purpose of the operations implemented by the hardware in the block diagram is to extend the intelligibility and speech quality of a voice communication system. Improvements are for any set of audio communication channel conditions.

A data source of original speech 20 provides an input for the system, which is compressed by a voice coder or vocoder 25 and a channel coder/interleaver 30. An output digital signal is modulated by a modulator 40 and transmitted through a channel 50. The data receiver 15 has a demodulator 60 that provides the signal to a channel status estimator 110 as well as to the channel decoder/de-interleaver 70. A voice decoder or synthesizer 80 provides decompressing of the voice, which is then input to a data sink 90 as the reconstructed speech. The voice decoder 80 also produces a spectral distortion indicator to the channel status estimator 110.

The coded data word starts with system status bits S(i) that are used to control the transmitter and receiver states to optimize the voice transmission. The initial bit is coded to indicate if the transmitter has changed state. If the transmitter state has been changed, the next bits provided a coded new state indicator for changing the receiver to the optimum transmitter state.

If the transmitter state has not been changed, the next bits transmitted after the initial bit are speech bits. This results in increased efficiency in the channel. Based on the symbol data rate of the modem, critical operating points (OP_{crit}) are computed by the system state estimator 100 and coupled to the channel 50. The state estimator operation is dynamically adjusted based on the operating parameters. The channel status monitor function 120 updates the $OP_{crit}(i)$ to $OP_{crit}(i+1)$.

These critical operating points, $Op_{crit}(i+1)$, determine the optimum voice coding rate in voice coder 25, channel coding rate and channel coding strategy in channel coder/interleaver 30, and

modulation/demodulation process in modulator 40, communication channel 50, receiver demodulator 60, channel decoder/de-interleaver 70, and voice decoder 80. The system state estimator dynamically determines operating parameters and continuously /dynamically adjusts operation of the receiver and transmitter.

Present state of the art vocoder systems have a fixed symbol rate, so that the optimum operating parameters can only provide a voice quality for a mild change in the communication channel conditions. If the channel conditions change sufficiently, the previous operating parameters are no longer optimal for providing the maximum speech quality possible given the new set of channel conditions.

In the present invention, new critical operating points are determined in the system state estimator 100 so the system can operate optimally for current channel conditions. The system is adaptive to varying communication channel conditions such that the optimal speech quality and intelligibility is obtained.

Channel status is defined as the state of the channel that requires critical operating points. Status is denoted as $OP_{crit}(i)$, for optimal speech quality and intelligibility for the i^{th} channel condition.

The channel status estimator 110 measures the quality, signal to noise ratio (S/N), and symbol error rate (SER) or bit error rate (BER) of the received signal. The value of the $OP_{crit}(i)$ parameter determines the condition (or status) of the voice communication channel.

The critical operating points are determined according to the communication system's BER (or SER) versus the S/N and bit sensitivity performance. Thus, as the channel status changes, so must the critical operating points $OP_{crit}(i)$.

The initial state of the system can be set at a reasonable expected channel condition, based on the average signal quality, S/N, and BER (or SER) measured during operational testing of the system in the field or under expected operational conditions.

The initial state is set by the transmitter 10, sent through the channel as a state indicator and decoded by the system state

estimator 100 in the receiver 15. The system state estimator then outputs the critical operating points for the system at the current channel condition. The state is a result of the transmission, and is denoted as $OP_{crit}(i)$. All of the encoding and decoding processes are based on the $OP_{crit}(i)$.

The adaptive receiver constantly monitors the received signal quality, S/N, the speech objective quality measure, and BER (or SER) and responds by way of a feedback channel to the adaptive transmitter's channel status monitor.

If the channel statistics have been determined to have changed significantly enough, the channel status monitor 120 at the transmitter then computes a new set of critical operating parameters for the system. This means that $OP_{crit}(i) \neq OP_{crit}(i+1)$, where if the channel statistics were determined not to have changed significantly, $OP_{crit}(i)$ would be very similar or equal to $OP_{crit}(i+1)$. The magnitude of the change in the channel statistics will thus determine which critical parameters change and to what degree of change is required.

FIG. 2 and 3 provide the flow diagram for one implementation of the software for an optimal voice coder receiver in the present invention. FIG. 4 provides the flow diagram for one implementation of the software for an optimal voice coder transmitter in the present invention.

Referring to FIG. 2 for the receiver, the voice coder system is initially synchronized, block 12, with the channel state vector or channel state indicator equal to zero, csir = 0. The ith received signal is input (block 62) to the receiver and then decoded in block 72 to provide the current system state indicator S(i). The system state indicator S(i) is evaluated by the system state estimator to determine validity, block 74. If it is valid (Y = yes), the critical operating parameters are compared to the previous one, $OP_{crit}(i)$ is compared to $Op_{crit}(i-1)$ at block 76. Unequal parameters (N = no) results in the $OP_{crit}(i)$ being updated to reflect the present S(i), block 86 and is used to demodulate and channel decode / de-interleave the received coded signal, block 94. For equal $OP_{crit}(i)$ parameters in block 76, the $OP_{crit}(i-1)$ is not changed from $OP_{crit}(i)$, in the block 84 and is used to

demodulate and channel decode/ de-interleave the received signal, block 94.

If the system state S(i) in block 74 is not valid, the system determines an approximate decoded system state vector $\hat{S}(i)$, block 78. This provides an approximate new state indicator. The receiver then demodulates and channel decodes / de-interleaves the data based on $OP_{crit}(i)$ equal $Op_{crit}(i-1)$ or $\hat{S}(i)$, block 88.

The receiver then estimates the signal quality, (SIG_{qual}), signal to noise (S/N) ratio, BER, and SER, in block 96. The voice decode or synthesis is performed with $Op_{crit}(i-1)$ or $\hat{S}(i)$, block 82 and input to the data sink, block 92, which completes the receiver decoding, block 97.

An objective measure of speech quality is then determined, block 87. This is used as the input A to FIG. 3 for continuation of the receiver flow diagram. Referring to input A on FIG. 3, the channel status vector or channel state indicator CS(i) is estimated, block 112.

The S(i) is evaluated in the receiver, block 98, to determine the validity of the system state, S(i). If S(i) is valid, it is compared to the CS(i), block 102. If the two are not approximately equal, then CS(i) is sent to the transmitter and the counter csir is set equal 0, block 118. If the two are approximately equal, then S(i) is sent to the transmitter and csir = 0, block 116.

If S(i) in block 98 is not valid, then $\hat{S}(i)$ is compared to CS(i), block 104. If approximately equal, then CS(i) is sent to the transmitter and the counter csir is set to zero or csir = 0, as in block 114. If $\hat{S}(i)$ is not approximately equal to CS(i), block 104, then the csir counter is incremented or set csir = csir +1, which is block 106.

The counter is checked to determine if the counter has exceeded a predetermined limit or Block 108 compares if csir > Ncrit. If it is not, then block 124 sends CS(i) to the transmitter.

If csir is greater than Ncrit, in block 108, then a resynchronization signal is sent to the transmitter, block 122. In either case, this ends the processing in the receiver on the *i* th channel status symbol, block 126.

FIG. 4 provides one means of implementing the transmitter for the present invention. At initial power up / synch and re-synch, the state vector S is set to the initial value, and the csit counter is set to zero, or csit = o, block 14. The *i* th channel status symbol is input, block 16. Next the channel status required is decoded from the receiver, CS(*i*) in block 18 to determine if the transmitter needs to be changed.

The validity of the channel status, CS(*i*), is checked in block 24. If CS(*i*) is valid, then block 22 computes S(i+1) based on the CS(*i*). Then the S(i+1) is compared to S(i), block 26. If they are not equal, then the transmitter updates critical operating parameters OPcrit(i+1) according to parameter S(i+1), block 34.

If the system state indicator has not changed, the critical parameters are the same, or if S(i+1) = S(i) then OPcrit(i+1) is equal to OPcrit(i), block 32. If the channel state indicator, CS(*i*) is not valid, block 24, an approximate channel status $\hat{CS}(i)$, block 28 is determined. Next an OPcrit is determined from $\hat{CS}(i)$, block 36.

Finally, voice code or vocode of the input, channel code/interleave and modulate based on the OPcrit, block 38 is performed. This ends the transmitter function, block 42, and provides the output on FIG. 1 for transmitter 10.

The output then is sent over the channel 50 of FIG. 1 to the receiver 15 for decoding as the *i* th received signal, block 62, on FIG. 2.

It will be noted that the invention can be applied to any digital data communication channel and is not limited to voice coding systems. Thus imagery, secure data or other digital communication could be improved by the optimal communication system of the present invention.

Although the preferred embodiment of the invention has been illustrated, and that form described in detail, it will be readily apparent to those skilled in the art that various modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims.

CLAIMS

-What is claimed is:

1. An apparatus for an adaptive rate communication system characterized by:

a transmitter (10) for transmitting signals from a source through a channel;

a receiver (15) for receiving said signals from said transmitter, said receiver coupled to said transmitter through said channel;

said receiver including a state estimator (100) for dynamically determining operating parameters; and

said state estimator dynamically adjusting operation of said receiver based upon said operating parameters, said state estimator coupled to said channel.

2. An apparatus for an adaptive rate communication system as claimed in claim 1, wherein said state estimator determines whether said operating parameters are changed to new operating parameters, said state estimator operating said receiver to process said signals in response to said new operating parameters, and

wherein said receiver further includes a demodulator for producing a signal-to-noise ratio in response to said new operating parameters, said demodulator coupled to said channel and to said state estimator, and

wherein said demodulator further produces a symbol error rate (SER) in response to said new operating parameters, and

wherein said demodulator further produces a signal quality measure in response to said new operating parameters.

3. An apparatus for an adaptive rate communication system as claimed in claim 2, wherein said receiver further includes a channel decoder for producing a bit-error-rate (BER) in response to said new operating parameters, said channel decoder

for decoding said signals, said channel decoder coupled to said demodulator, and

-wherein said channel decoder produces a forward error control (FEC) in response to said new operating parameters, and

wherein said receiver further includes a voice decoder for producing a speech distortion indicator in response to said new operating parameters, said voice decoder for decompressing said signals, said voice decoder coupled to said channel decoder, and

wherein said signals include means for indicating a change of said operating parameters to said new operating parameters.

4. An apparatus for an adaptive rate communication system as claimed in claim 3, wherein said receiver further includes a channel status estimator operating in response to said signal-to-noise ratio, or to said bit-error-rate, or to said speech distortion indicator to determine whether said signals are properly received by said receiver, said channel status estimator coupled to said state estimator, to said demodulator, to said channel decoder and to said voice decoder, and

wherein when said channel status estimator determines that said signals are improperly received by said receiver, said state estimator further operating said receiver in response to estimated operating parameters, and

wherein:

there is further included a feedback channel; and

said transmitter includes a channel status monitor for receiving said new operating parameters from said channel status estimator through said feedback channel, said channel status monitor coupled to said channel status estimator through said feedback channel.

5. A method for an adaptive rate communication system characterized by the steps of:

(42) transmitting signals from a transmitter through a channel;

(62) receiving said signals by a receiver from said transmitter through said channel;

(76) dynamically determining operating parameters by a state estimator of said receiver; and

(86) dynamically adjusting operation of said state estimator in said receiver based upon said operating parameters.

6. A method for an adaptive rate communication system as claimed in claim 5, wherein said transmitting step includes a step of sending a state indicator to said receiver, said state indicator including operating parameters, and

wherein there is further included steps of:

determining by the receiver whether said state indicator is valid;

when said state indicator is valid, determining whether said operating parameters are equal to current operating parameters; and

when the operating parameters are not equal to the current operating parameters, updating said current operating parameters to be the operating parameters, and

wherein there is further included steps of:

demodulating said signals with said current operating parameters; and

channel decoding said signals with said current operating parameters, and

wherein there is further included steps of:

when said state indicator is invalid, approximating a new state indicator;

update said current operating parameters based on said new state indicator;

demodulate said signals with said current operating parameters; and

channel decode said signals with said current operating parameters, and

-wherein there is further included steps of:

estimating a signal-to-noise ratio of said signals received by the receiver;

estimating a bit-error-rate (BER) of said signals received by the receiver; and

estimating a symbol-error-rate of said signals received by the receiver.

7. A method for an adaptive rate communication system as claimed in claim 6 wherein there is further included steps of:

voice decoding said signals with said current operating parameters; and

determining a speech distortion.

8. A method for an adaptive rate communication system as claimed in claim 7 wherein there is further included steps of:

estimating by a channel status estimator a channel state indicator in response to said signal-to-noise ratio, to said bit-error-rate (BER), to said signal quality, said symbol-error-rate and to said speech distortion;

determining whether said state indicator is valid;

when said state indicator is valid, determining whether the channel state indicator is equal to state indicator;

when the channel state indicator is equal to state indicator, sending state indicator to the transmitter; and

when the channel state indicator is not equal to state indicator, sending the channel state indicator to the transmitter.

9. A method for an adaptive rate communication system as claimed in claim 8 wherein there is further included steps of:

when said state indicator is not valid, determining whether the channel state indicator is approximately equal to the new state indicator;

when the channel state indicator is approximately equal to the new state indicator, first sending the channel state indicator to the transmitter; and

when the channel state indicator is not approximately equal to the new state indicator, second sending the channel state indicator to the transmitter.

10. A method for an adaptive rate communication system as claimed in claim 9 wherein, when the channel state indicator is not approximately equal to the new state indicator, said step of second sending includes steps of:

incrementing a counter;

determining whether the counter exceeds a predetermined limit;

sending a resynchronization signal to said transmitter, when the counter exceeds the predetermined limit; and

performing said step of second sending, when the counter does not exceed the predetermined limit, and

wherein said step of transmitting includes steps of:

determining whether said channel state indicator received from said receiver is valid; and

determining a transmitter state indicator from said channel state indicator received from said receiver, if said channel state indicator is valid, and

wherein said step of transmitting further includes steps of:

determining whether said state indicator is equal to said transmitter state indicator;

when said state indicator is not equal to said transmitter state indicator, updating said transmitter state indicator to be said channel state indicator; and

determining said new operating parameters from said transmitter state indicator.

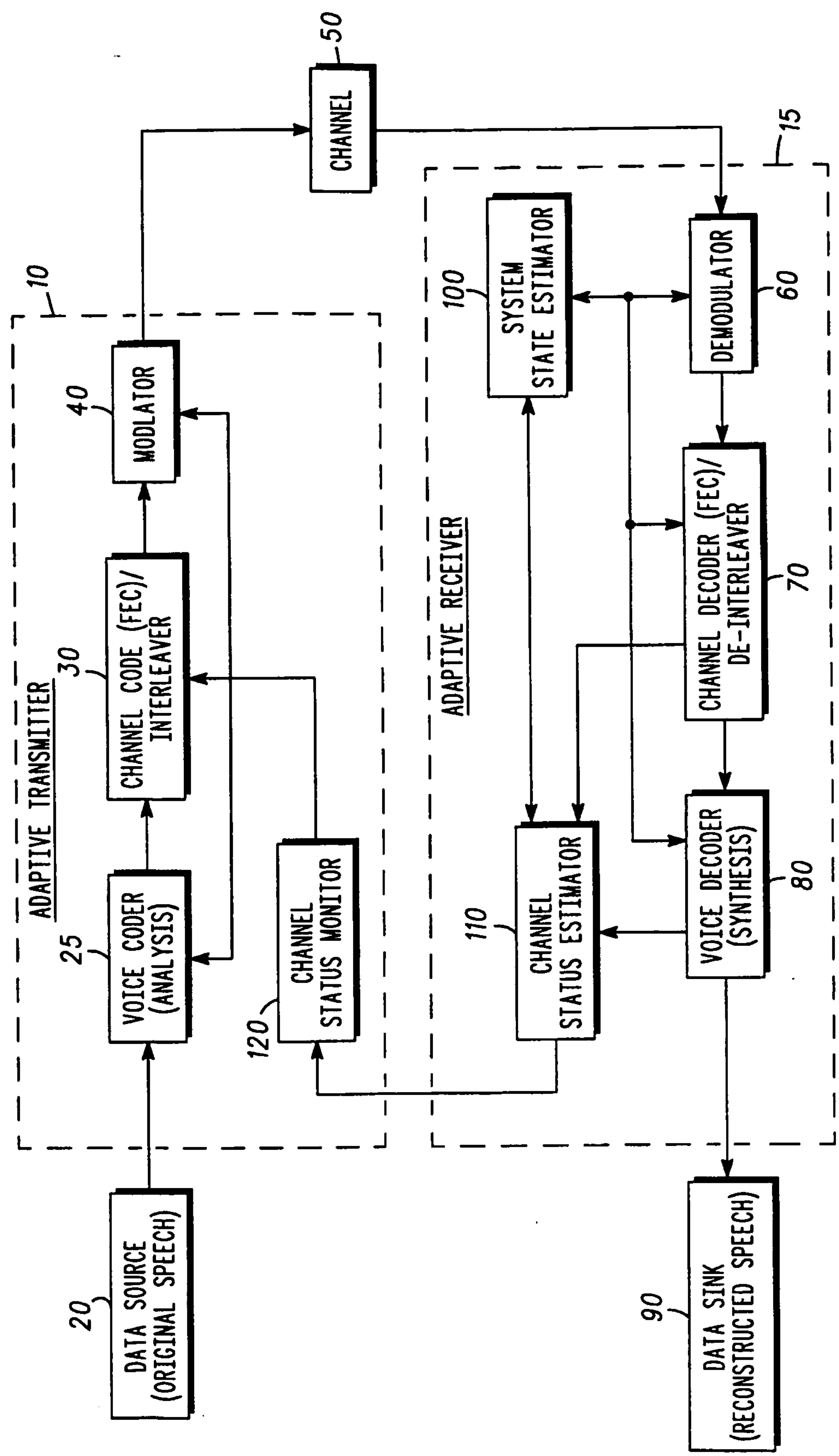

ADAPTIVE TRANSMITTER
10
DATA SOURCE (ORIGINAL SPEECH)
20
VOICE CODER (ANALYSIS)
25
CHANNEL CODE (FEC)/ INTERLEAVER
30
MODLATOR
40
CHANNEL
50
CHANNEL STATUS MONITOR
120
ADAPTIVE RECEIVER
15
SYSTEM STATE ESTIMATOR
100
DEMODULATOR
60
CHANNEL DECODER (FEC)/ DE-INTERLEAVER
70
VOICE DECODER (SYNTHESIS)
80
CHANNEL STATUS ESTIMATOR
110
DATA SINK (RECONSTRUCTED SPEECH)
90

FIG. 1

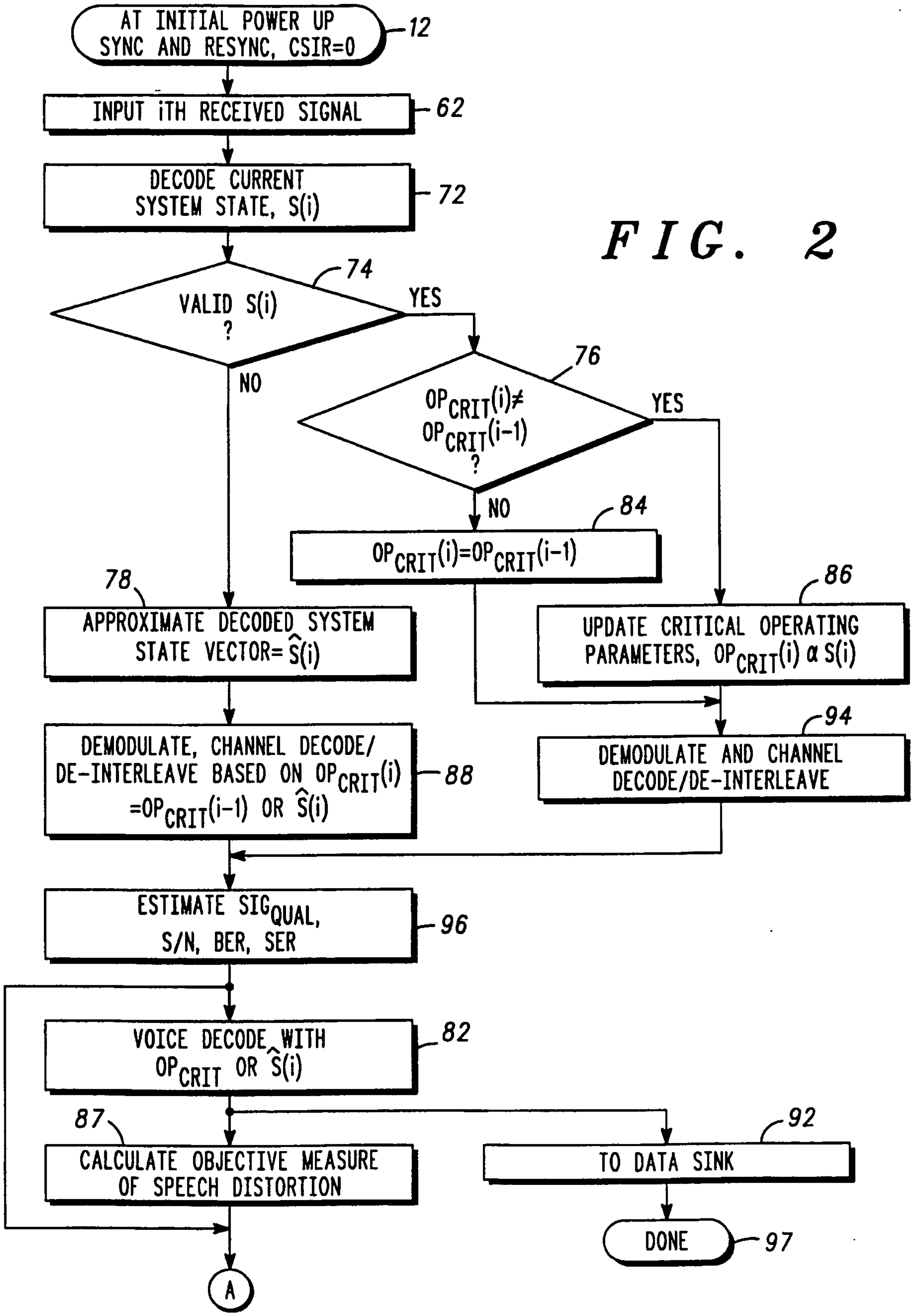

AT INITIAL POWER UP SYNC AND RESYNC, CSIR=0
12
INPUT iTH RECEIVED SIGNAL
62
DECODE CURRENT SYSTEM STATE, S(i)
72
VALID S(i) ?
74
YES
NO
OP CRIT(i)≠ OP CRIT(i-1) ?
76
YES
NO
OP CRIT(i)=OP CRIT(i-1)
84
78
APPROXIMATE DECODED SYSTEM STATE VECTOR=Ŝ(i)
UPDATE CRITICAL OPERATING PARAMETERS, OP CRIT(i) α S(i)
86
DEMODULATE, CHANNEL DECODE/ DE-INTERLEAVE BASED ON OP CRIT(i) =OP CRIT(i-1) OR Ŝ(i)
88
DEMODULATE AND CHANNEL DECODE/DE-INTERLEAVE
94
ESTIMATE SIG QUAL, S/N, BER, SER
96
VOICE DECODE WITH OP CRIT OR Ŝ(i)
82
87
CALCULATE OBJECTIVE MEASURE OF SPEECH DISTORTION
TO DATA SINK
92
DONE
97
A

FIG. 2

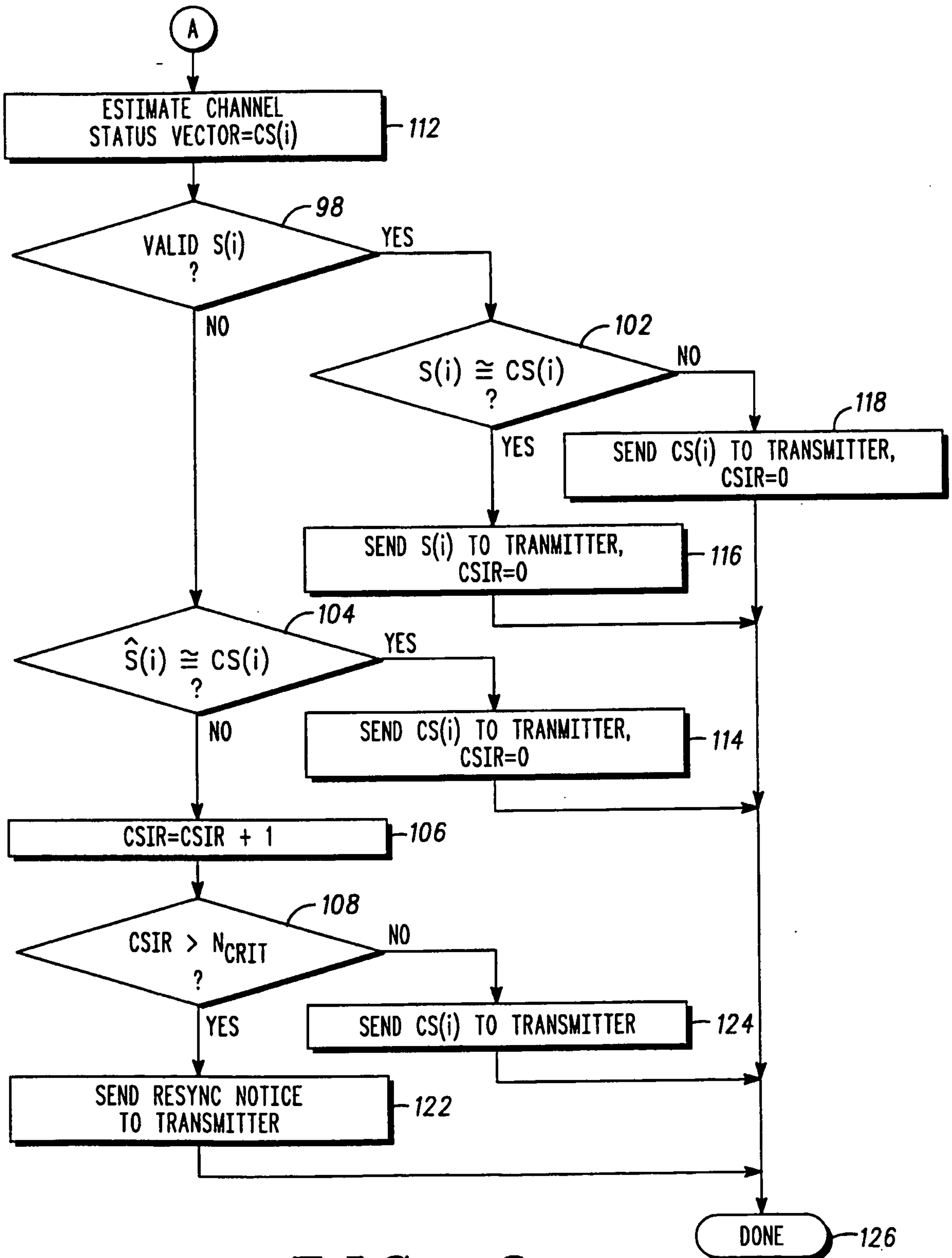

A
ESTIMATE CHANNEL STATUS VECTOR=CS(i)
112
98
VALID S(i) ?
YES
NO
102
S(i) ≅ CS(i) ?
NO
YES
118
SEND CS(i) TO TRANSMITTER, CSIR=0
SEND S(i) TO TRANMITTER, CSIR=0
116
104
Ŝ(i) ≅ CS(i) ?
YES
NO
SEND CS(i) TO TRANMITTER, CSIR=0
114
CSIR=CSIR + 1
106
108
CSIR > NCRIT ?
NO
YES
SEND CS(i) TO TRANSMITTER
124
SEND RESYNC NOTICE TO TRANSMITTER
122
DONE
126

FIG. 3

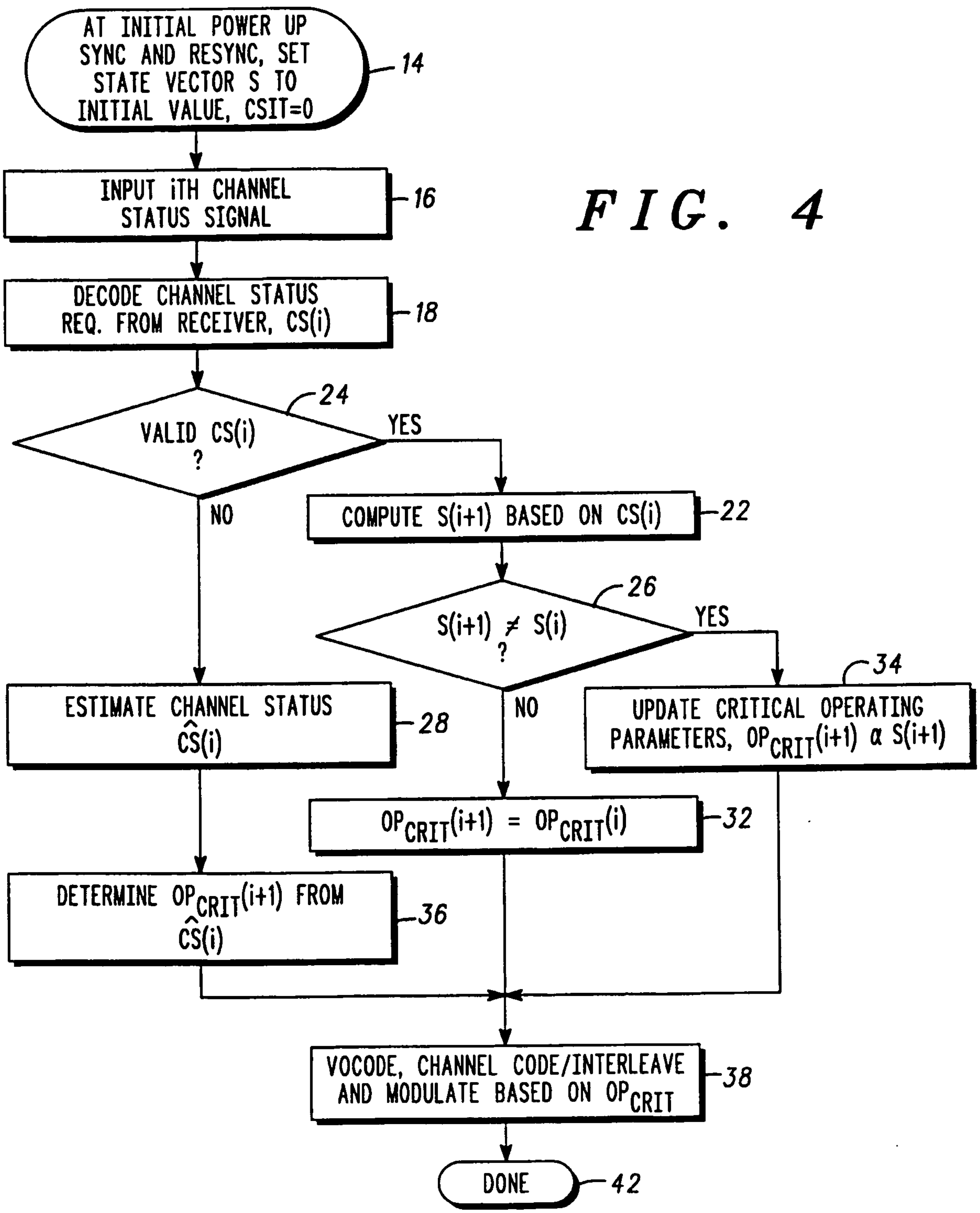

AT INITIAL POWER UP SYNC AND RESYNC, SET STATE VECTOR S TO INITIAL VALUE, CSIT=0
14
INPUT iTH CHANNEL STATUS SIGNAL
16
DECODE CHANNEL STATUS REQ. FROM RECEIVER, CS(i)
18
VALID CS(i) ?
24
YES
NO
COMPUTE S(i+1) BASED ON CS(i)
22
S(i+1) ≠ S(i) ?
26
YES
NO
UPDATE CRITICAL OPERATING PARAMETERS, $OP_{CRIT}(i+1) \alpha S(i+1)$
34
ESTIMATE CHANNEL STATUS $\hat{CS}(i)$
28
$OP_{CRIT}(i+1) = OP_{CRIT}(i)$
32
DETERMINE $OP_{CRIT}(i+1)$ FROM $\hat{CS}(i)$
36
VOCODE, CHANNEL CODE/INTERLEAVE AND MODULATE BASED ON OP_{CRIT}
38
DONE
42

FIG. 4

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/00276

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04L1/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	YUEN E ET AL.: "VARIABLE RATE SPEECH AND CHANNEL CODING FOR MOBILE COMMUNICATION" PROCEEDINGS OF THE VEHICULAR TECHNOLOGY CONFERENCE, STOCKHOLM, SE, vol. 3, 8 - 10 June 1994, INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, pages 1709-1713, XP000497714	1,5
Y	see sections I, II-E	2-4,6-9
A	see figure 1	10

	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

2

Date of the actual completion of the international search	Date of mailing of the international search report
14 May 1998	20/05/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Ghigliotti, L

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/00276

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 95 28814 A (ALCATEL MOBILE COMM FRANCE ;ALCATEL AUSTRALIA (AU); LE STRAT EVELY) 26 October 1995 see page 1, line 19 - page 2, line 4 see page 5, line 11 - line 25 see page 7, line 2 - line 21 see page 10, line 15 - line 23 see page 16, line 8 - line 10 see page 16, line 20 - page 17, line 8 see page 18, line 4 - line 27 see figures 2,8-10 ---	2-4,6-9
X	US 4 110 558 A (KAGEYAMA SATOSHI ET AL) 29 August 1978 see column 7, line 14 - column 8, line 10 ---	1,5
X	WO 92 22162 A (BRITISH TELECOMM) 10 December 1992 see page 4, line 35 - page 5, line 18 see page 7, line 12 - line 26 see page 8, line 8 - line 14 see page 10, line 30 - line 32 ---	1,5
X	EP 0 154 565 A (CODEX CORP) 11 September 1985 see page 8, line 11 - line 30	1,5
A	see page 17, line 27 - page 19, line 15 ---	10
A	JACOBSMEYER J M: "ADAPTIVE DATA RATE COMMUNICATIONS FOR HIGH FREQUENCY RADIO CHANNELS" MILCOM '91, MILITARY COMMUNICATIONS IN A CHANGING WORLD, MCLEAN, VA., vol. VOL. 3, no. -, 4 - 7 November 1991, INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, pages 938-942, XP000273837 see page 940, right-hand column, line 30 - page 941, left-hand column, line 25 see page 941, right-hand column, line 21 - line 25 ---	1,5,10
A	WOODARD J ET AL: "A DUAL-RATE ALGEBRAIC CELP-BASED SPEECH TRANSCEIVER" PROCEEDINGS OF THE VEHICULAR TECHNOLOGY CONFERENCE, STOCKHOLM, SE, vol. 3, 8 - 10 June 1994, INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, pages 1690-1694, XP000497710 see section 2 -----	

2

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 98/00276

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9528814 A	26-10-95	FR 2718906 A	20-10-95
		AU 2311295 A	10-11-95
		CA 2187669 A	26-10-95
		EP 0755615 A	29-01-97
		FI 964043 A	04-12-96
		JP 9512672 T	16-12-97
		NZ 284502 A	20-12-96
US 4110558 A	29-08-78	JP 1047095 C	28-05-81
		JP 52092413 A	03-08-77
		JP 55037894 B	01-10-80
		CA 1061912 A	04-09-79
WO 9222162 A	10-12-92	AT 162035 T	15-01-98
		AU 656972 B	23-02-95
		AU 1772492 A	08-01-93
		CA 2110578 A	10-12-92
		DE 69223961 D	12-02-98
		EP 0587620 A	23-03-94
		ES 2112318 T	01-04-98
		JP 6507763 T	01-09-94
EP 0154565 A	11-09-85	US 4756007 A	05-07-88
		CA 1253229 A	25-04-89
		DE 3584176 A	31-10-91
		JP 1980563 C	17-10-95
		JP 6095666 B	24-11-94
		JP 61001130 A	07-01-86